Space Archaeology with Alice Gorman
Ologies Podcast
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Oh hey, it's the friend whose calls you always pick up because if they are actually wanting to speak instead of text with their phone it must be either really good or really bad news, Alie Ward, and that one is very true. I'm back with an episode of this show called *Ologies*.

I'm going to try and make this intro as speedy as I can. The race to get to space junk! This episode is so good. Thank you to everyone at Patreon. Did you know it costs $1/month to join and then you can submit questions to ologists? Patreon.com/Ologies. Thank you also to everyone who rates, who subscribes, who leaves reviews. I read the hell out of all of your reviews, then I aim a laser pointer at one each week such as, dear Wuzzlr who wrote:

> *I'll be honest I didn't like podcasts.* ([*Alie interjects skeptically*] Okay…) *But Ologies has had me hooked since day one.*

Then Wuzzlr called me, "an informed closet goblin," and I thank them for that. If you left a review this week, or ever, I have read it and I have appreciated it.

Okay onward to space archaeology. Space, that word's been around since the 1300s, coming from Latin's *spatium* which means 'room' or 'area'. By the mid-1700s it meant the cosmic expanse, the stellar landscape, the crushing enormity of nothingness which is filled with everything, including all of our secrets. And maybe some broken glass and someone's car keys. The archaeology part comes from the Greek *arkhaiologia,* the study of ancient things, which will be discussed.

Patron Kevin Beamer posted on the Patreon.com/Ologies community board. They said: I'd like to nominate three related but distinct ologies: astroarchaeology – the study of how people in the past understood and used astronomy; remote sensing archaeology – the use of satellites and other remote sensing techniques to help with archaeology of stuff on Earth; and space archaeology – the study of human artifacts in space.

Kevin Beamer? Space archaeology; we're doing it. A lot of folks on Twitter also pointed me toward this particular ologist. Her Twitter handle is @DrSpaceJunk. [*swoons*] Ah, say no more! She got her PhD in archaeology with a specialty in stone and glass tool use post-colonization, and has worked for years in Indigenous heritage management. She is a member of the Australian Institute of Aboriginal and Torres Strait Islander Studies and is President of the Anthropological Society of South Australia. She's also a member of the Advisory Council of the Space Industry Association of Australia.

She is an Associate Professor at Flinders University in Australia and is recognized as a world expert in orbital debris and launch sites. She's also a TED speaker. She writes the *Space Age Archaeology* blog, is the Vice Chair of the American Institute of Aeronautics and Astronautics, Adelaide Chapter, *and* is a founding member of the Archaeology, Science and Heritage Council of the non-profit organization For All Moonkind, Inc., which helps protect cultural archaeology sites in space. On top of all this, she somehow found time to author the book, *Dr Space Junk vs The Universe: Archaeology and the Future*.

We got on the horn when it was afternoon in LA and the future in Australia, and every so often you might hear the delicate tinkling of a spoon against her mid-morning tea. So strap in, helmets on, for

a chat that covers everything from Sputnik to sports cars, cosmic litter, flaming garbage, machines raining down on fields, alien debris, collision potential, radioactive rubbish, clean up possibilities, the cutest space garbage, burials in the void, and how does one do archaeology without sitting on a rocket to get to work, with Dr Space Junk; Space Archeologist, Dr Alice Gorman.

[*intro music fades and launch countdown begins: "Ignition sequence starts. 6… 5… 4… 3… 2… 1…*]

Alice Gorman: Oh, so I'm Alice Gorman and I am she/her.

Alie Ward: Okay, cool. [*launch countdown continues: "Liftoff! We have a liftoff!"*]

Alie: Do you think that you may have been one of the first space archaeologists? Was this a thing before?

Alice: I think I probably was one of the first ones. I wasn't *the* first one and I was not the only one back then, and I'm not the only one now. When I think about it, there was something going on in the year 2000. My colleague, Beth Laura O'Leary, who's from New Mexico State University, started thinking about cultural heritage on the moon. Bizarrely, there were actually a few people in Australia who were thinking about space archaeology as well. You wouldn't think Australia would be a big space archaeology hub, but I had a couple of colleagues who were thinking about the Moon and Mars and also the much broader kind of xeno archaeological/astrobiological thing as well. But, around the year 2000, it all started to come together. We all met each other. We started running conference sessions together and we started developing the ideas and the principles.

More importantly, we started trying to get a bit of credibility with the broader archaeological community. We all focused on different things. I started with space junk and that's continued to be one of my major research interests and obsessions. Others were working on the Moon, Mars, terrestrial space sites, rocket launch sites, that kind of thing. This little group of us just started putting stuff out there, trying to build a profile for the idea that this very recent stuff actually had things to tell us about how we operate in the world and might have heritage value. Now 20 years on, I think we've achieved that.

Alie: Yeah, it makes me wonder, how old does something have to be for it to be archaeological? Did we have to wait until we had gotten enough junk up there and it was old enough? Does it have to be 30 years, 10 years? Can something be archeological if it's only 10 minutes old?

Alice: My answer to that is: absolutely it can be. There's a couple of interesting things going on with this idea. One is, when does the past actually start? Isaac Asimov actually wrote a very interesting short story about this called "The Dead Past." A time machine had been invented, and there was an archaeologist who was desperate to go back to ancient Carthage and see what happened. He kept applying for permission to use the chronoscope and kept getting turned back. In the end, he was so persistent that he found out why no archaeologist or historian was allowed to use the chronoscope to look into the past. It is because the past could start a millisecond ago and such a machine is actually a powerful surveillance tool.

So it's an interesting story, but it makes the point that our definitions of the past are pretty arbitrary, and things that are a thousand years old don't necessarily have more heritage value or more ability to inform us about human behavior than things that are 10 minutes old. Archaeology, at the end of the day, isn't about old things. It's about human interaction with material things. That means that you and I, sitting at our desks right now, are creating an

archaeological layer that somebody could come along and interpret once we got up and left the desk.

Aside: Hear that? If your workspace is a repository of chaos, type up a museum placard. Sling a velvet barrier in front of those moldy coffee cups and unopened bills. These artifacts must remain undisturbed and unjudged.

Alie: I have heard that a lot of archaeology deals with discarded items, or shall we say, just historical garbage. That garbage is like *chef's kiss* when it comes to an archaeologist. Is that true? Is that true for archaeology, space junk, *and* the work that you were doing with Indigenous cultures in Australia?

Alice: You're right, Alie. Your standard archaeological site is what's left behind. It's people's rubbish. It's structures and buildings that existed at the moment people left, died, or moved to another location. So, you're looking at what's left. Space archaeology fits into what we're calling the archaeology of the contemporary past, another kind of paradox. It's the past of 10 minutes ago, again. So, this isn't always stuff that people have abandoned or discarded. Often it's stuff that people are actually using or living in; the International Space Station, being a great example of that.

Aside: Just a side note for context: The ISS, the International Space Station, is a joint effort by several countries with the top contributors being NASA, Russia's space program, and the European Space Agency (ESA). The ISS launched into the void of eternity in 1998 and has been taking a low, hovering lap 248 miles above your face, just circling Earth every 90 minutes pretty much since the Clinton-Lewinsky scandal erupted and Titanic came out. Between three and ten people are up there at any given time, defying what our ancestors could ever even imagine was possible; doing experiments, making music videos sometimes, and peeing into a suction hose. What a blast!

Also, the US had a different space station named Skylab but in 1979, five years after the astronauts bounced and left it uninhabited, its orbit started to decay and it got sucked back into our gravitational pull. Because it was so large and chunky and made of some pretty hardy metals, pieces as big as a small car crashed into an Australian sheep field, scattering parts that were gathered and put in a modest tourist museum.

Alice: So these objects and sites are still often active and people have relationships to them. This does add another ethical dimension to doing this kind of archaeology. It also gives you huge advantages because you can ask people what was going on at a place. But, you make a good point, there is an intersection with Indigenous archaeology here. This was my main career before I became a space archaeologist.

I was a heritage consultant working with Aboriginal communities in Australia. For those communities, similarly, you don't say, "Oh, this is a hundred years old so it has a different kind of value." A lot of the value comes because things are still very present and interwoven in everyday life. It does give you a different kind of sensibility about stuff that is recent, and definitions of rubbish as well. Something that is not being used, or appears to have been abandoned, when we're looking at the present, that's not necessarily the case.

Aside: So while archaeology means 'the study of ancient history', that's not always the case in practice. The significance of an artifact might have everything to do with the cultural significance of its… [*pauses sheepishly*] impact, so to say, and how we interacted with it, whether it was something accidentally left behind or deliberately abandoned. But what kind of objects are we talkin'?

Alie: How do you define space junk? I picture broken satellites and a booster that's just up there rusting. What is it exactly?

Alice: My answer to that relates to what we've just been talking about because I'm kind of really uneasy with the term 'junk'. There's all kinds of other words for things that are discarded or considered to be waste. We have, 'trash', and 'garbage'; all of these kinds of words. There is actually a definition of space junk, a technical definition. It says, "a piece of space junk is an object that does not now or in the foreseeable future have a use."

Aside: Let's repeat that, because it's important: [*Alice repeated with a robot filter*] "A piece of space junk is an object that does not now or in the foreseeable future have a use."

Alice: So, that's the kind of engineering definition. The kinds of things people routinely think of as junk are all of the old and abandoned satellites, rocket bodies and fragments of those objects that are floating around in Earth orbit. You could also technically say that places like the Apollo landing sites on the moon are junk because they have been abandoned or discarded by some definitions.

But the way I look at it, our definition of junk is a very cultural thing. Something that one person abandons or discards may actually have very high value for somebody who is from a different place, or class, or has a different understanding of material objects.

Aside: Hey, one person's trash is another's treasure, and this applies to everything from old barbecues to romantic partners, and that's beautiful.

Alice: We do have examples of spacecraft which ceased to be used but were still capable of being used. So they did actually have a use in the foreseeable future. Some very clever people have gone out and reactivated old spacecraft, old satellites, to repurpose them for – [*Alie gasps*] I know, isn't that amazing?

Alie: Yes, that's great! That's like, when you watch a program on Discovery where it's like someone in the Rust Belt putting together an old Chevy and getting it to run again. [*clip from Rust Valley Restorers: "Turn it over!" engine rumbles, followed by an exited high-pitched shout*] That's some serious technological makeover. How do they do that? Are they able to do it from Earth and just get some codes and start tippy-tapping?

Alice: Yes, a lot of the time it is as simple as that. They just need to get the codes. But the really interesting thing is those codes are often lost. This is the case with the UK satellite Prospero, which had its 40th anniversary a few years back. A group of students tried to reestablish contact with it, but the codes had been lost in, like, an office move or something.

Alie: [*exasperated*] Oh god! It's like they need LastPass. Or it's all lowercase password123. [*both laugh*] Just try 1234! See if it works!

Alice: It's such an interesting thing because we have this idea of the space age as something that's very orderly and where nothing goes wrong, where technology is perfect. It's the same kind of thing. You clear out the filing cabinet in your office and you throw out *the one file* that had the things that you needed in it and suddenly there's a spacecraft adrift that nobody can use again.

I think around this idea of junk, that's really interesting. Things that are considered junk may still have social uses, for example. An example I often think of when it comes to that is a rather famous red sports car that was launched into space in 2018, by a rather famous space person. [*Elon Musk: "I think it looks so ridiculous and impossible. You can tell it's real because it looks so fake, honestly. We'd have way better CGI if it was fake."*] It was quite controversial

when it was launched because people said, "Why couldn't it have been a proper scientific experiment? We could have got something out of it." Other people said, "This is amazing. It's visionary. It's whimsical and quirky." And you know, I love a bit of whimsy and quirk with the best of them, but it was a red sports car and we know what red sports cars symbolize, or should I spell it out, Alie?

Aside: Oh wait, am I missing something? Are we talking about a different kind of space *junk*? [*snickers*]

Alie: I'm thinking it's just very much a midlife crisis and a phallic symbol, but…

Alice: Very much, but it's also wealth and power, representing membership of an elite organization. There's probably lots of other meanings that you could find, but the point about that red sports car, it didn't do anything. It didn't collect data. It wasn't part of any experiment, but its function was social. Its function was to be a symbol. So, for all of the people who said, "Oh, it's just another piece of space junk, clogging up the orbital parts of the solar system," even though I personally dislike the symbolism, it makes a wonderful argument that the function of a spacecraft can be social. And if that's the case, then it isn't actually junk, even if it's not working.

Aside: Just some quick trivia on this, I looked it up and Elon didn't get the idea of launching his roadster into space while he was on a kratom bender in a hot tub. Apparently SpaceX announced that they needed a boilerplate, or a dummy payload for the Falcon Heavy test launch, and they were looking for the silliest ideas possible. One Twitter user, someone by the name of Evelyn Janeidy, a 20-something Texan, self-described as a Latina writer and poet, who's also a trained dental technician, but a cosmos enthusiast and aspiring SpaceX employee, suggested launching Musk's swanky commute vehicle into orbit. Musk faved it, and the internet took a vote. The rest is history that will last roughly a billion years.

So whether the car is a whimsical nod to human potential, or an egomaniacal automotive version of gas station dick pills, just this object existing has a function, because we're talking about it and we're thinking about it. Which might be its greatest use: a marketing tool.

Alice: That's a very archaeological sort of way to look at things. I think something that we do as archaeologists is to look at everyday objects… sometimes really special objects, but often it's just everyday objects and look at them beyond their strict function to see what roles they perform in creating social cohesion, supporting certain power structures, or undermining certain power structures. So, an artifact or an object is never *just* that. There's always more going on, because that's how humans work.

Alie: Yeah, there's context behind every artifact in every museum. That artifact, when it's interpreted with context, has so much more social and emotional value for sure.

When it comes to a timeline here, we haven't been catapulting things into orbit for our entire existence on Earth. So, what do you think was the first piece of space debris that was up there? When did we start flinging stuff?

Alice: There's a rather wonderful story that, I think in the early 1950s, a nuclear explosion in an underground cavity, which had what is often called a 'manhole cover' on the top, actually caused that manhole cover to jet off the Earth and get into Earth orbit. This was in the early '50s and many people say this is the first thing that actually made it into space properly.

Alie: I am freaking out about that! That's crazy to think that there's a manhole cover somewhere up there that's the first piece of space junk. [*gasp*] Okay.

Alice: There does seem to be some evidence that this story isn't apocryphal and may actually have happened. And of course, we've got a difference here between things that can get high. Like they get super high [*clip from Pineapple Express: "Now it's time to get super-duper high!"*] and be in space, but they don't stay in space. They just come straight back down. So really, if we're looking at the first objects that got into Earth orbit, we have Sputnik 1 in 1957, and I often think about this.

In 1957, the first time that a human object that people can watch for and listen to, [*Sputnik 1 beeping sound*] Sputnik 1 had a little beep-beep-beep radio signal that became absolutely iconic. How extraordinary that must've been to think that there was a human object up there with the stars above your head. Of course then, later that year the Sputnik 2, which had poor little Laika the dog on board.

Aside: Why poor little Laika? What happened? Laika was a Russian dog plucked from the streets and quite literally thrust into fame as the first living creature to orbit Earth. She was launched in the 13-foot-tall Sputnik 2, the month after Sputnik 1 went up. Her name means The Barker and she only survived a few hours because the temperature controls failed, but her body continued to orbit the planet 2,570 times over the course of 5 months before a cremation caused by incineration reentering the atmosphere. Truly a rags-to-riches-to-ashes tale. But it got people very fired up about travels unbound by gravity.

Alice: Then you had the first US spacecraft. So, by 1958, it's not an extraordinary thing anymore. There's two or three up there at any one time. Then suddenly it's like, boom! [*rocket launch countdown, crowd cheering, announcer says "lift off"*] This whole thing takes off. Every year more and more and more, until we get to the point here in 2020, where there is going to be a predicted 30,000 Starlink satellites manufactured by SpaceX in Earth orbit in the next 10 years. At the present time, there are around about 2,000 functioning satellites, maybe around 4,000 not functioning whole satellites, and over 35,000 bits of junk that are greater than 10 centimeters.

So going from 1957, when there's just that one little beep-beep-beep up in the sky, to 2020 when we're looking at the night sky changing so radically that in fact the easiest things to see *will* be human manufactured objects. They will be spacecraft and satellites, and this will be part of people's everyday experience of going out at night. That's an extraordinary change.

Aside: I'm going to repeat those figures just to wrap our brains around them. So, 2,000–3,000 working satellites are up there now, plus 4,000 defunct old ones. There are 35,000 bits of space junk bigger than the palm of your hand, and millions of smaller, shall we say, microjunk. Soon 30,000 *new* satellites will join – five times the number that are up there now!

SpaceX can launch something like this, because as a private cosmos courier service, they have made launches much more affordable for themselves. So, why not go into the satellite business itself instead of just being a for-hire satellite delivery business for other companies, is their reasoning. Astronomer Dr. Samantha Lawler wrote via the website *The Conversation,* "We're about to undergo a dramatic transition in our experience of satellites. No longer will you escape your city for a camping trip and see the stars unobstructed: you will have to look through a grid of crawling, bright satellites no matter how remote your location." She states that Starlinks are lower in orbit and brighter than 99% of other satellites out there.

Other folks justify their presence saying that they are mostly visible at dawn or dusk. My good friend Casey Handmer is in the rocket science business. He writes a great space blog

and said, “Starlink’s world-spanning internet will bring high-quality internet access to every corner of the globe.” Highlighting Starlink’s enormous power for bringing about positive change he writes:

> *The internet is able to help people hold leaders to account, communicate with people in other places, share ideas, invent new things, and unify the human race. The history of modernity is one of increased capacity for human data sharing. First, through speeches and epic poetry. Then writing, which enables the dead to speak to the living, data storage, and asynchronous communication.*

He continues by likening this development to the printing press. So naturally, these unnatural objects, possibly up to 42,000 of them, have cheerleaders and detractors. I keep thinking of the Billy Bragg lyric, “I saw two shooting stars tonight. I wished on them, but they were only satellites.” Maybe we just need to start wishing on Starlinks and hoping for the best.

So, technology bleeding out toward the edges of our unknown spaces – does that rate of advancement rely on these private space tech companies? Well there’s Wright’s Law, which bases the exponential progress of technology on the number of iterations of something produced. But what about the Moore’s Law, observed in the early computing days?

Alice: Moore’s law is the idea that I think every two years computing power doubles. We’re still seeing that hold, and obviously spacecraft rely very much on computing power to do their jobs. I think one of the interesting things that is going on here is there’s a constant tension between the services that can be delivered on the ground using terrestrial infrastructure and the services that can be delivered by satellite. Things like navigation, telecommunications, and various other things aren’t always best done by satellite.

Aside: Now, the terrestrial way we get our phones to light up with essentially portable omniscience is mostly via phone circuits, fiber optic systems, cell towers, and broadband cables. Those long-ass wires have to go over the rivers and through the woods and across the oceans but they stay on Earth as opposed to circling above.

Alice: When we’re looking at the movement of telecommunications into Earth orbit, as we’re seeing with the proposed Starlink satellites and other massive, massive constellations that have been proposed for the future, that’s not a necessity. We don’t *have* to run our telecommunications like that. These are technological and political choices, I guess. As an archaeologist, this is the sort of thing that’s interesting to me. What kind of social background leads to decisions being made which mean we end up being very space-reliant and vulnerable?

A massive solar flare, for example, could take out navigation, communication, and Earth observation satellites – take them offline – which happens from time to time. Then what do we do if we don’t have backups on Earth? What do we do if we’re over reliant on having space-delivered internet? There’s a lot of repercussions.

Alie: That’s maybe looking forward to the future, but as they exist now, do you have any space artifacts up there that are close to your heart or that particularly vex you?

Alice: There are so many amazing artifacts in Earth orbit and so many that deserve to have their stories told more widely and to be appreciated by a much wider range of people. When people say, “space junk.” I do have some that I feel very fond of. One of my all-time favorites is Vanguard 1, which was the second US satellite and is now the oldest human object in Earth orbit. I think that’s pretty special.

It's kind of beautiful, too. It's a polished silver sphere with six antennas sticking out and it's got a very sort of retro vintage feel, and it's kind of friendly and warm. You know, it's been out there all this time. It's seen everything happen. Once upon a time it had only had a few other neighbors. Now it's part of orbit that's starting to look busier and busier with all these new kids on the block. I just think about what it's seen during its time in space. So, I'm very fond of that satellite.

Aside: I mean, how can you not be? The thing is a 3-pound shiny little sphere that can fit in one hand, and one Russian politician nicknamed it, 'The Grapefruit' because it's the size of a grapefruit, I guess? But a really big grapefruit. More like a pomelo, which is like… a big grapefruit.

Sidenote: I had to google it. And googling, I found out that grapefruits are an invention, and they're a cross between the pomelo and the sweet orange. Most of the world didn't even know about them until 1750 when they were found being cultivated on a Caribbean island and then deemed the 'Forbidden Fruit', because there's really nothing tastier or sexier than, I guess, a grapefruit.

So when American launched Vanguard 1 in 1958, the year after Sputnik went up, maybe the Russian leader called it a grapefruit, but meant a pomelo! I mean, for a size comparison, it would've been more accurate but I guess weirder to call it, 'the baby's head'.

Alice: Another of my favorites is an amateur satellite launched by a group of Australian students called Australis-OSCAR 5. It was launched in 1970, but they started to design it and build it in the mid-1960s. It's part of a whole sequence of amateur satellites that started in the early 1960s and is going today. I love that story. You know, we think of space as being about the incredibly wealthy nations, the spacefaring nations with all of their technology and all of their brilliant scientists. I love that there's a whole tradition of satellites, probably 50 or 60 of these amateur satellites in orbit.

These are just people saying, "We want to get involved in space." A lot of small nations actually use this amateur program to launch their first satellites as well, so I love this. This is just about regular people getting involved in space, and it's such an important tradition to acknowledge and to talk about.

If I think about some of the spacecraft technically called "junk" that I've become obsessed with recently… I do tend to move through different phases of obsession about these things. There's a series of experimental satellites for testing radar that were launched throughout the '60s and two of them, I love. They're called Dodecapole 1 and a Dodecapole 2.

Aside: Okay, these puppies were about the size of an uncomplicated beach ball and just adorable.

Alice: And their nicknames are Porcupine 1 and 2 because they were, like Vanguard 1, a little polished silver sphere and they had 12 antennas, and these antennas were 12 feet long each. So they really do look extraordinary! If you can just imagine that, a little silver ball with these incredibly long legs sticking out of it. To me they're beautiful. And they're still up there in orbit right now. So they're space junk too, but they tell a story of spacecraft design. Those experimental projects in the early decades of the Space Age when people were just testing equipment, and systems, and how things work.

Alie: How much is flotsam? How much is jetsam? How much is accidentally like, "Whoops, there goes a Capri Sun bottle!" How much is, "We've gotta cut this thing loose"?

Alice: There's certainly a lot of accidents that happen in space.

Alie: Okay! [*laughing*]

Alice: Something gets up there, it just doesn't work. Just doesn't work! Nobody can turn it on. Something gets up there and one of its solar panels fails to unroll, so it doesn't have the energy it was supposed to have, and it can't operate fully, or something gets up there and just [*whispered, "Kaboom!"*] explodes. There are all kinds of reasons why things don't work. And interestingly, space insurance is a *huge* industry.

Alie: Is it really?!

Alice: Yes, there's a whole space insurance industry!

Alie: Oh my gosh! What are the deductibles like? Can you imagine? [*Alice laughs*] They're like, "Full coverage?" and you're like, "Yes, please." I can't even imagine what a fender bender on like a Falcon is. Oh god. And a Dragon module.

Alice: We think of space as being about the rockets and the satellites, but in fact there's this whole web of connected industries as well, which I think is interesting. Usually a satellite will be launched with an idea of what its mission life is and everything will be planned around that. It might get to that time and everything's going great, so they extend the mission life. The satellite keeps working. It's still got teams of people devoted to keeping it in its orbit, to getting the data, to sending updates to its codes. All of that stuff.

Sometimes it gets to the end of its mission life and there's no compelling reason to keep it going so they just stop using it, even though it might have fuel and battery and actually be physically capable of functioning well. But to keep a satellite working in orbit requires teams of people and those resources are sometimes needed elsewhere. So there could be all kinds of reasons why a satellite just sort of stops being used. Whether you then say it's "junk," if technically it could be reused, or how you classify it, in fact it would be really interesting. As far as I know nobody's ever made a list of satellites which have the capability of being reused.

Alie: Well, there you go, you just inspired someone's career!

Alice: I hope so, I hope so! Usually when a satellite gets reused, it's by an amateur group, but there are plenty of people with those skills out there and putting an old satellite to use collecting new scientific data would be an amazing thing to do.

Alie: Well, that leads me to a question that keeps nagging at me because I imagine that as an archaeologist, you do a lot of site work, you collect a lot of data, you go back, you analyze it, you crunch numbers, right? What do you do if the objects you need to study are tens of thousands of miles away? How do you study it?

Alice: It's true, archaeology is such a physical discipline. We're camping in remote locations… well, they're not always remote, sometimes they're in the middle of cities. But we're out there walking the land. We're excavating things, getting covered in dirt, doing physical labor. We're walking through gorges and across beaches and mountains, and really, we're *present* in these places. Part of the joy of archaeology is its physicality, I guess. So, you're right. It's a bit of a paradox. I can't go to space. I can't see the objects that I'm studying. I have to rely on proxies. I have to rely on catalogs, and data, and scientific papers, and visualizations, and things like that. So, it is a bit different to normal archaeology.

I spend a lot of time visualizing and imagining the spacecraft that I'm looking at. I will take a dry paragraph from some scientific paper and in my mind, spin it into a vision of a particular spacecraft. One example of this is, at one point I was doing a lot of work on all of the Russian landing craft on Venus.

Aside: Okay, this was in the 1960s and *Venera* means Venus in Russian! And it wasn't until right now that I learned that "venereal" comes from Venus, the Roman goddess of love. They didn't name it a venereal probe, and that's good.

Alice: Everybody said surface conditions on Venus are so harsh that they're just melted puddles of metal. I thought, "Well, we don't know that!" I started trawling through all the scientific papers about surface conditions on Venus and what the spacecraft were made out of. We do have pictures of them before they left Earth. We also have artists' visualizations of the Venera landers when they got to the surface of Venus.

But you'd find little things in the papers that suddenly made you realize that those pictures were very incomplete. There was one U.S. surface mission to Venus called Pioneer Venus, and the landing craft had little windows made out of sapphires and diamonds.

Alie: [*gasps*] Whaaat?!

Alice: And this is just a little detail in the paper that describes its technology and, exactly, you're thinking, "Sapphire and diamond eyes. That's beautiful." That's just an engineering detail, but for an archaeologist, it's that kind of stuff that helps me relate to them as physical objects and then, I hope, convey to other people that these are just so much more than a complicated bit of metal on a planetary surface.

Alie: I also have so many questions from patrons. I told them you were coming on the show. They launched [*Fozzie Bear from The Muppets*: *"Wakka wakka!"*] a lot of questions at you. So, I'm just going to say them in their words.

Aside: Okay, but before we get to your very good questions, let's toss some money toward a good cause chosen by Alice. This week it's going to Deadly Science, which provides STEM books and early reading material to every remote school in Australia. It was founded by STEM communicator Corey Tutt, himself a Kamilaroi man, who saw that some remote schools had just 15 books in their whole school library. So, Deadly Science has now shipped over 14,000 books, 500 telescopes and chemistry sets, plus other resources, to over 112 schools with more to come. Deadly Science wants to ensure all schools have access to our history of science by providing First Nations resources to connect back to our first scientists.

There'll be a link to Deadly Science in the show notes in case you also want to throw some dollars their way, and our donation was made possible by the following sponsors of the show, whoms I like.

[*Ad Break*]

Okay, your questions, starting with one that was orbiting a lot of your brains.

Alie: Okay, one of the most repeatable questions I got: Radha Vakharia, Anna Thompson, Andrew G, Soph Cousineau, Jenn 'Squirrel' Alvarez, Mason Turner, Heather Densmore, Justin McCormick, Matt D, Sebastian Osterbrink, and Julia McDonald, all wanting to know, essentially: How often does it fall to earth?

Alice: Ah, it's a very good question. This is one of the other things about space junk. Once the satellite stops being used, its orbit can't be controlled, or isn't controlled, so things that are

low enough get affected by atmospheric drag. The atmosphere starts to lower their orbit and pull them back in. [*"Oh dear."*]

So the answer to that question is that every day bits of space junk get dragged back into the Earth's atmosphere and burn up. They're not always large bits and they're not always whole satellites, but I would say probably once a week, there's a whole satellite or a large piece of space junk that re-enters. You can actually go and find out. There are sites which track these re-entries.

Alie: Ohh my gosh! Really?! [*laughs*] So it's like, "Forecast: Bonked by space junk."

Alice: That is pretty much it! There are two levels of forecast. One is what's going to re-enter the atmosphere. And the good news about this is stuff mostly completely burns up. The risks of being hit by space junk are incredibly low.

Then there's what's looking like it will likely collide actually in Earth orbit. That's what's really concerning because those collisions in orbit create more space junk, which will collide with more space junk, and more space junk, and all of that. But if people are really interested, they can to CelesTrak, AstriaGraph, Heavens-Above, SeeSat-L, and a number of other satellite catalogs that you can easily find on Google, and you will be able to get the updates on what's looking like it will re-enter.

Alie: Oh, great.

Aside: Of course I looked this up, and all those tiny glowing dots sparkling like seed beads spilled over a rendering of Earth – it's a bit boggling to see. It's even color-coded so the sheer number of thousands of dead satellites up there is really apparent. Just cruising, like very expensive ghost ships in the night. As I was staring at these animations though, there was this peculiar march, and I clicked on it. They were Starlinks, all in a line like a Mardi Gras necklace encircling the planet. Just staggering to see.

Alie: To expand on that a little bit, several different patrons, Gwen Kelly, who is a terrestrial archaeologist, first-time question-asker Pim Bongers, with a great name, also first-time question-asker Julia Chirka, Malorie Albee, first-time question-asker Meryl Stark, Kasia Wisniewski, and my buddy JR Roloff asked: Does space junk want to become bigger and bigger blobs or does space junk's orbit decay and just fall into the atmosphere? JR asked: Is space junk clearing itself more slowly than we're replacing it? Also, why was *Firefly* cancelled? He's got a lot of questions. [*Alice laughs*] Did you ever see *Firefly*? I guess there's an episode about space junk.

Alice: I didn't ever see it, but I know it had a very devoted following, so I wish I knew the answer to that.

Aside: JR, I gotcha. It seems this Joss Whedon sci-fi futuristic western, which aired for just 11 episodes in 2002, had a terrible Friday night timeslot. Just unfortunate. Also, Fox aired all the episodes out of order! Then the series finale titled, "Objects in Space" (haha, I see why you asked now) wasn't even supposed to be the finale at all! So, RIP *Firefly.* [*clip from Firefly: "Well, here I am."*]

Alice: There's a lot of stuff in there. One is that we are in fact putting more things into orbit, which create more junk, than is being dragged into the atmosphere. So that is one of the problems at the moment. I think at the beginning there was a question about whether bits of space junk tend to kind of coalesce into blobs. And while there are, of the really tiny, tiny fragments… So the size of space junk goes from the size of a house down to microscopic sub-

millimeter level. Little tiny, tiny particles, and there are millions and millions of these. Some of them, depending on their origin, are in little clouds, but it's not really a blob.

Most of the outer planets in the solar system have ring systems. We all know Saturn's beautiful rings, but in fact, Neptune has rings. Uranus has rings. [*repeated in low pitch: "Uranus has rings."*] Yeah, I said it, and I'm not backing down from that either! [*Alie cackles*]

Most of those planets actually have rings. In the inner solar system, Mercury, Venus, Mars, Earth, do not have rings. But there was a very famous paper written in 1970 by Donald Kessler, after whom the Kessler syndrome is named, and Burton Cour-Palais, and they tried to figure out if Earth could get its own ring system made out of space junk, [*Alie gasps*] which I actually think could be quite beautiful.

Aside: Alice says the good/bad news is…

Alice: We don't have enough space junk to get a ring system that would form naturally. Apparently there's not enough mass, which means blobbiness and clumpiness... we might not get any mini moons that are made of space junk all mushed up together like a breccia or something like that. So it's an interesting question about orbital dynamics to think about why that is.

Maybe part of that is we know we have to clean space junk up. People often think I'll be upset about this. They'll say, "Alice, people will get rid of these artifacts that you love!" I'll say, "Well, if it's part of the natural evolution of the space industry, I would like them to keep the beautiful stuff which has a lot of cultural significance if it's a low risk. But if it's a high risk, then heritage isn't enough to counteract that."

But we will have to get rid of some of it, and for some of it the best solution is to push it higher, out of the way of the high-density orbits. We actually have a graveyard orbit at the moment, which is out beyond the geostationary orbit, which is where telecommunications satellites are, about 35,000 kilometers high above the earth.

Alie: Wow.

Alice: It's quite a complicated task to get something that high. When these satellites get to the end of their life, ideally they have enough fuel left to boost them just a bit higher, about 500 kilometers above, into the graveyard orbit.

Alie: [*softly*] Wow.

Alice: So we do kind of have a design-structured ring in that graveyard orbit, but without it being controlled the spacecraft tend to sort of drift out and drift away and there's not enough gravitational weight to hold them together. But maybe in the future, we might think about making some kind of structure out of all of this space junk into… I don't know what you'd call it, astro-engineered art? That might be something we could do.

Alie: The biggest Burning Man installation in the universe. [*Alice laughs*] Just welded space junk.

Carolyn Butler has a very serious question, wants to know: Are there 500 billion single unmatched socks floating out there, and if not, any insight on where they might be?

Alice: If we're going to take the precedent from *The Hitchhiker's Guide to the Galaxy* and the biro pens that have gone missing over the years, all of those socks are not currently in Earth orbit. They are on some other planet, somewhere. [*Alie laughs*] There haven't been any sightings of socks, so I regret to say until that planet is discovered, we're just going to have to live with our sock situation.

Aside: So, something is *afoot* on another planet, perhaps.

Now, speaking of extraterrestrial matters, Kate H., Jessie Dragon, Sadie Baker, Annalyssa Ramirez, RJ Doidge, they all had the same question. In patron Samantha Healey's student Peter's words: Have you found unidentified space junk from somewhere that is NOT Earth? Something that we don't know what it is, from somewhere we've never been?

Alie: A lot of patrons wanted to know: Do we ever see any alien space junk? Like what about the [*uncertain*] Oumuamua?

Alice: Oh, yes. So, I will probably not pronounce it correctly, but Oumuamua [*YouTube pronunciation: "Oh-mua-mua"*] was an extrasolar object that just barreled into our solar system at very high speed, did a bit of a sort of gravity bend around the sun, and then took off again. It's inclination and speed indicated it had come from a very long distance away. Somewhere in the galaxy. There was some speculation particularly by one astrophysicist [*clip of Avi Loeb: "Oumuamua is the very first interstellar object to have been discovered in the solar system, sort of like having a guest for dinner."*] Avi Loeb that this was an alien spacecraft or some kind of alien object.

Now, I can't say that it isn't, but scientific consensus is that it is not an alien object. We might revise our opinions about that if we get to observe other similar objects. We don't know when they're going to come. The appearance of that object was a surprise. No one knew that it was on its way. But when we have a little bit more to compare with, it might be possible to be clearer about that.

Now, for alien things in Earth orbit, there is actually a bit of a conspiracy theory about an object called the Black Knight.

Alie: Oooh.

Alice: The Black Knight is supposed to have been in orbit around Earth for 13,000 years, so it's not made by humans. This pops up every now and then. I get Black Knight conspiracy theorists emailing me because they think… I try to be generous and respectful when I get these sorts of queries, but they often see space and archaeology combined and think that I will be somehow less scientific than other space scientists or astronomers they've approached. I regret to say that isn't the case. [*Alie laughs*] But I do get queries about this and there is no evidence that anything other than objects manufactured by humans has ever been in Earth orbit.

Alie: One listener Cassy Flint, on that note, asked: Is there any kind of space junk, real or potential, that scares you to your core?

Alice: Oh gosh! [*laughs*] Well, there's one piece of space junk that I and many others find very worrying. I don't know if it *scares* me to my core, but… Oh, actually, there *is* one that scares me to my core, but I'll do the first one. There's a European Space Agency spacecraft called EnviSat, which was an Earth observation scientific satellite launched in 2002, I think. It's huge! The size of two double-decker buses. It's now a piece of space junk and it's uncontrolled. If anything hits it, it will create *so* much space junk that the effects are going to be really, really bad.

Alie: Oh no.

Alice: But we also haven't got any way of getting it out of orbit at the moment, so I find that quite scary. All we need is for something big enough to hit EnviSat and create hundreds of thousands more bits of debris and we have a pretty bad situation in Earth orbit. So that's scary, but what really terrifies me, if we're going to talk about visceral terror…

Alie: Yeah! Yeah!

Alice: …is an experimental space station called Genesis 1, or it could be Genesis 2. There are two Genesis inflatable space stations, empty, currently in Earth orbit. They were made by Bigelow Aerospace and they're related to the technology of the inflatable module being tested on the International Space Station right now. These space stations were sent up, and because nobody was ever intended to live in them or visit them even, they were sent up with various interesting or funny objects. One of them has [*drumroll*] Madagascar hissing cockroaches.

Alie: [*gasps, laughs*]

Alice: Now, we know that cockroaches are basically predicted to be able to survive a nuclear holocaust. Cockroaches are hardy, and don't tell me I'm wrong, cockroaches are smart.

Alie: Oh they are! Absolutely.

Alice: So it worries me that someone deliberately sent cockroaches into space, and at some point that spacecraft might be deorbited, or maybe someone will go inside and we will have found that our real problem isn't the space junk. Our real problem is space cockroaches who have evolved and mutated and are coming to take us over, and I'm not even joking.

Alie: Oh my god! I wonder if they're out there nibbling on tardigrades, maybe. [*Alice laughs*]

Alice: Yes, we sent food up for them! What were they thinking!?

Alie: Apple cores and just cheese rind, a pizza crust, just floatin' around. Ugh!

This actually dovetails perfectly into first time question asker, Marie Honoré, who asked: How dangerous is space junk? Is it radioactive or toxic?

Monica also asked: Is there any special decontamination process after things have crash-landed on Earth? Can we get space junk down and what do we use on it? Like, Purell?

Alice: That's a really great question. I should say, if anybody is in a situation where a piece of space junk has survived falling out of orbit and has landed near them, don't go and touch it.

The first thing is, some spacecraft fuels are quite toxic. Hydrazine is one of those; it's very commonly used. Fuel tanks are among the more robust parts of your average satellite, rocket, or spacecraft. They're made out of stainless steel or titanium aluminum alloys. They're quite robust, but that fuel is toxic. Don't touch it. There are other spacecraft materials like beryllium, for example, which is a metal. People might remember the beryllium spheres from *Galaxy Quest*. [*clip from Galaxy Quest: "The beryllium spheeere"*] That is also toxic. Do not touch it.

If a piece of space junk lands near you, first of all, it's not finders keepers. It actually belongs to the launching state. You can't take it and sell it on eBay. Don't touch it. Alert your nearest governmental authority, perhaps space agency if you have one, environmental protection agency, something like that. As for decontamination processes, I would say don't undertake them yourself. I'm not sure what you would do, but not touching these objects is… You'll hardly ever be in this situation because not that much actually survives down to the surface.

But the other interesting question is nuclear fuel. There is now a standard that nuclear fuel is only used for deep space missions, but there are quite a few satellites in Earth orbit that are powered by RTGs.

Aside: RTG, you ask? I had the same question. That's a radioisotope thermoelectric generator or a nuclear-powered battery. It's just full of that good, good juice.

Alice: They have plutonium, for example. It's not the same as a nuclear reactor, we don't have any satellites powered by a nuclear reactor, but we do have nuclear fuel, if you see the difference.

In 1978, the year before Skylab re-entered, there was a very terrifying, and at the time I think a largely hushed up incident, where a Russian Kosmos spacecraft re-entered the atmosphere and it had nuclear fuel. The Kosmos re-entered, broke up, and the nuclear fuel was scattered over a broad area in the Arctic Circle, over forests. There were Indigenous communities who lived in these areas and it was highly, highly toxic. It took a massive international cleanup effort to try and recover all those bits of fuel.

The good news is that there are still spacecrafts in Earth orbit that have nuclear fuel, but as far as I know, none of them are a massive risk, but it is worth keeping in mind; another reason not to go near space junk. You could go and look up the predictions and work out if the predicted thing to re-enter near you is something which does not have nuclear fuel. You can do that, but you couldn't guarantee its toxicity in terms of other products and materials that are used in spacecraft.

Alie: Right.

Aside: Are human remains ever shot into space? Oh, you bet they are. But usually, they're already ashes and they orbit and re-enter the atmosphere and burn up with all the flamboyance and indulgence of a twice-baked potato.

Also, it should be noted that Dr. Eugene Shoemaker, one of the founders of planetary science, is just NBD chilling on the moon. Some of his ashes were delivered there by NASA. Just the ultimate backstage pass. You gotta know someone though.

That space funeral question was asked by Felix and Kasen Wally. And on the topic of *Wall-E*, Erin Unson, Michelle Neer, and Felix Lasselle have been harboring questions about it since 2008.

Alie: A lot of people wanted to know how you felt about the movie *Wall-E*, where there's essentially just a shell of garbage around Earth. Any thoughts? Are we going to let it get to that point do you think?

Alice: What you see in the film *Wall-E*, and in fact it's an incredibly evocative scene, [*majestic music with Wall-E squeaking*] little Wall-E the garbage robot clinging to the rocket, which punctures this thick layer of space junk, really thick, and Sputnik 1 gets caught in Wall-E's hands [*sweet bell-like music with Wall-E saying, "Oh!"*] or a bit of the rocket. I actually show that film to my classes when I'm teaching space archaeology and contemporary archaeology. It's a beautiful, fun film, but there's a lot going on in there.

It's a really graphic representation. It's not an *accurate* representation, because space junk, in fact, is very far apart. You would never see something that looked like that in *Wall-E*, but the point of that scene in *Wall-E* isn't to accurately represent a future situation with space junk, exactly. It's a metaphor. It's a warning. It's part of the degradation of the surface of Earth as you see it in that film literally covered in garbage with only cockroaches and robots alive, and then you go to space and you see the devastation that has been created in Earth orbit.

I think it's a very powerful piece of the film, but the thing to remember is that space junk is in fact… I can't think of a good visualization. When people see those images that space agencies

have made showing the distribution of space junk, they're usually not to scale so you do get the impression things are very close together, but it actually isn't like that.

I suppose if we did make our own planetary ring out of space junk it might look a little bit like that scene you see in *Wall-E*. *Wall-E's* such an interesting film because it's also got a strong heritage theme in it. Wall-E's little collection of objects that he doesn't always know what they're for, that he finds aesthetically pleasing or they speak to him in some way. So, if you haven't seen *Wall-E*, I'm pretty sure most people would have, but it really is worth looking at.

Alie: Aaah, I haven't seen it yet, so now I have to!

Alice: [*gasps*] No!!!!!

Alie: I know! I haven't seen it yet, but I understand I'll bawl my eyes out at some point during it.

Alice: I'm afraid you will.

Alie: Yes, okay. [*laughing*] I'll report back.

Aside: As soon as I watch *Wall-E*, you will know, because I will tell you about my emotional breakdown in the secret at the end of the episode, perhaps next week.

Oh, also, I took a Twitter poll, and 12% of you had no idea that I tell a secret at the end of each episode after the credits, which is amazing; so many things to go back and learn. Some of them you don't want to know, but have fun!

So, Matt D, Soph Cousineau, Wayne Hovey, Kasia Wisniewski, Starr, Misty Dulovich, and Kate H. asked: What's the next space junk collision event going to be?

Alie: A lot of people wanted to know: Are space agencies concerned about collisions with space junk?

Alice: Oh yes, there's a whole massive area of study, and policy, and law in the international space community that's called Space Situational Awareness, or SSA, that's basically about how to manage the space junk situation so that we can continue to use satellites for services like telecommunications, navigation, Earth observation, weather prediction, all of those things.

This is a massive concern. There is actually an international committee which is made up of representatives from most of the space agencies, whose job it is to look at this. The United Nations Committee on the Peaceful Uses of Outer Space has this as a major item on its agenda, so there's no need to be concerned that this is not on the radars of the people making the decisions.

We do have problems because it's not possible at this point in time to just whiz up there and pull out a dangerous piece of junk. There are technical issues with going into orbit to try and remove something. Then there are international relations issues because if you have the capacity to actively remove a piece of junk from orbit, you have the capacity to remove an active satellite, maybe a military one. So, "Oops! Sorry! Didn't mean to do that! Really sorry!" But, you know, this could be the cause of very serious conflict on Earth and in space. While we're still very much working on the technology, and there have been a couple of breakthroughs in recent times, that part of it we haven't made a lot of progress on. From my perspective, I think lobbying by the public could have an impact here.

Aside: How do you even start to do that? It's so much worse than cleaning out your closets. Okay, well first off, it costs money to go to space. A lot of it. That's kind of a thorny business issue first, Alice says. But all kinds of propositions have been made, from nets, to land-based

lasers, to an 18-mile cloud of fine tungsten dust that sweeps lighter particles into re-entry with it, burning as it accelerates toward Earth. But what about a space tugboat?

Alice: A little space tug sent up in this way would have to take so much fuel with it to get more than just one thing that it hardly becomes worth doing.

There are lots and lots of proposals for different kinds of methods. Last year there was a successful test of the harpoon method, in which a spacecraft would spear a little harpoon out into space which would pierce the body of a piece of space junk, and then it could be maneuvered back into the atmosphere to burn up. This was done successfully in space. That was the first time we've had a test like that, but that's all it was. It was a test. It doesn't mean we can go out tomorrow and start spearing all of these objects.

There are all kinds of proposals for sails, and nets, and tethers. The standard at the moment is that if you are launching a mission, you design the mission to minimize the amount of space junk that it will create. Sadly, a lot of spacecraft operators don't do that at all because it often adds weight and expense to the mission.

Something that could be done would be to somehow figure out how to enforce compliance across the board so we're not continuing to create new debris. It's going to be a while, I think, before we've really got this problem under control.

Alie: Right, ugh. I was way too many years old before I found out that cruise ships just unload their toilets in international waters. Is that happening on the ISS? Are there space turds? [*Alice laughs*] Be honest with me.

Alice: I didn't actually know that about cruise ships.

Alie: Can you believe? They just open the hatch once you get like two miles from shore or something. It's horrifying!

Aside: Okay, it's not that close. It's not two miles. That was hyperbole. It's actually three miles. Three miles from whatever beach you're on, a floating city could be streaming port-a-potty slurry into the ocean with a fart n' a shrug.

Now, is it happening over our heads as well? Gloriously, patron Hollis had the same question.

Alie: But I wonder are there freeze-dried poos up there?

Alice: [*laughs*] Well, some of the Russian space stations used to eject liquid waste, as we call it, and there were stories that the Mir Space Station, which was de-orbited in 2001, was surrounded by a little cloud of frozen urine.

Alie: [*laughs*] Oh no!

Alice: People might be aware that the Space Shuttle windows used to be replaced regularly because they had been bombarded by little, tiny, tiny micrometeorites and bits of space junk. They're very, very expensive to replace. But some of them came back with little, tiny yellow streaks where it appears that a little tiny piece of frozen urine had plowed through the surface of the window.

As for solid waste, I don't think so, but I could be wrong. Most of this stuff would be in very low orbit and has likely re-entered. ["*Head's up!"*]

What they do on the International Space Station is they eject a lot of their waste in spacecraft which re-enter and burn up so it's not up there floating around. They do have to bring some

samples back for biomedical research as well. But the ISS is pretty clean; it's not contributing to turds in space.

Alie: [*laughs*] That's good to know. Well, I guess, on the topic of things that are crappy, what is the worst part about being a space archaeologist, either from something petty to something existential? What sucks the most about your job?

Alice: I guess I still sometimes encounter people who think it's ridiculous to look at the social, and symbolic, and political aspects of space endeavors in the 20th and 21st centuries, who think it's just about the technology. I also come across people who think, because I might be critical of some aspect of space policy or space industry, that this means I'm some unreconstructed Luddite who never wants to go to space. [*Alie laughs*] I do find these attitudes quite mystifying.

I'm not into justifying what I do, but if people come around eventually and think, "Oh well you know maybe this is important," that's fantastic, but I suppose there's a sort of hardcore, a *hardcore* hardcore of the space community for whom there are no ethical dimensions to what we're doing and there are no negative impacts on anyone. It can be quite interesting getting into those conversations.

Alie: I bet. What about your favorite thing about it? What still just gives you butterflies about it, even doing this for 20 years?

Alice: We know so much about human space exploration. There's so many books, archives, papers, oral history interviews and documents, you know? There's so much information to work with, but I will still come across odd little facts, personal stories, or weird things just hiding in some odd corner of an archive, or some casual statement that someone makes to me. There's so many amazing stories about human engagement with space and telling those stories, finding them, communicating, and sharing them, for me, is the most exciting part of being a space archaeologist.

Alie: And, of course, people can find that in *Dr. Space Junk vs The Universe: Archaeology and the Future*, I'm guessing?

Alice: Yes, lots of these stories made it into that.

Aside: How silky smooth was my segue there? It's just masterful. Also, it's just an excellent book.

Alie: Where can people find you? Because I know I'm gonna have dreams about space junk for decades. [*both laugh*] Where can people find where you're writing and where you're telling these stories?

Alice: So, you mentioned my book, *Dr. Space Junk vs The Universe: Archaeology and the Future*, so that's a sort of general overview of the field of space archaeology, also space history, a discussion of some of the ethical issues, and some of those stories that I love telling. They're all in that book.

You can also find me on Twitter @DrSpaceJunk. I talk a lot about space archaeology and heritage, and cake over there as well, so there will be cakes! You'll just have to live with that. [*Alie laughs*]

I also write a blog called *Space Age Archaeology* and that's often got things in it that aren't quite enough to write into an academic article, but just little thoughts and threads that I want to follow and investigate.

Alie: Oh, Amazing! Thank you so much. I'm so glad you got into my orbit and that I got into yours! [*both laugh*] Thank you so much for letting me ask you so many questions.

Alice: Well thank you Alie, your questions were very insightful as were those of the patrons. It has been a pleasure to talk about this with you.

So ask focused folks spacey questions, because how the hell else would you know about space pee and sacrificial cosmonaut dogs?

Do follow Dr. Alice Gorman on all platforms and get her book, *Dr. Space Junk vs The Universe: Archaeology and the Future*. There will be a link to all of that in the show notes.

You can follow me if you want to, @AlieWard on Twitter and Instagram. We're also @Ologies on Twitter and Instagram, so do be my friend. If you need a sweet *Ologies* gift, including a mask, order soon! Go to OlogiesMerch.com. The link is in the show notes. Thank you, Shannon Feltus and Boni Dutch for managing that. They host a very funny podcast called *You Are That*, so do check that out.

Thank you Erin Talbert, who admins the Ologies Podcast Facebook group full of really good human people. Thank you to Emily White and all the transcribers who help get free transcripts available for anyone who needs access to them. Those are at the link in the show notes. Thank you Caleb Patton for bleeping episodes so they are kid safe. Those are also on my website for free at the link in the show notes.

Thank you and happy birthday to ballerina and my right-hand lady, Noel Dilworth, who helps schedule all the guests. Thank you to the wise and wonderful Jarrett Sleeper of MindJam Media who not only assistant edits but has kept the trains running on time and gotten me into a better production schedule this week, which is very exciting.

Thank you as always to the mission control lead editor, Steven Ray Morris, who puts all my brain debris together. He also hosts *The Purrrcast* and *See Jurassic Right*, two really great podcasts. And Nick Thorburn wrote the launch and re-entry music and he's in a band called *Islands*.

Now, if you stick around past the credits, [*hushed excited voice*] maybe this is the first time you've ever heard me tell a secret! Jarrett and I happened to watch this new comedy special on Netflix called *Nate*, which is so good and so weird, and in the middle of it we just looked at each other 'cause we realized that we looked exactly like the two characters central to the show.

As a joke, we took a picture and put up a side-by-side pic. The star of the show saw it, and reposted it, and also said that we were the couple that inspired the whole show, which was fucking hilarious of her and also not true. We don't know her, but I had such a weird fangirl moment of being like, "Ahh! She noticed me! But also I hope no one takes this as the truth." Because if you watch the show you would know why.

But yes, the resemblance is uncanny. Particularly the hair. It's a very great, thought provoking special. It's called *Nate* on Netflix.

Okay, that's it. Don't be afraid to fail. Cut bangs, text your crush, huff some bark. All right, that's enough out of me.

Berbye.

Transcribed by:

Hana Snook, Wellington, New Zealand 🥲

Your Pal Aska Djikia

Anna Murray

Elizabeth Wheeler

That Christmas ornament that fell off the tree and rolled into the corner, Elena Horne

Edits by Mike Melchior

Some links that may be to your liking:

A donation went to Deadly Science: https://deadlyscience.org.au/

Alice's blog: Spaceage Archeology

Dr. Gorman's TEDTalk about lunar archaeology

Potty in space, FYI

The only international space junk law

"The Dead Past" short story about the time traveler

Carthage 101

"Starlink is about to ruin stargazing forever"

The pros of Starlink, by Casey Handmer

NASA's space debris visual simulation

How many people are on the space station?

Poor little Laika, the space doggo 14/10 would not launch again

Laika's last moments, detailed

The abandoned Skylab went boom into a sheep field

ISS history

Sputnik 2, carrying Laika

Is Moore's Law the Wright Law?

Dodecapole satellites, also known as Dodecahedron or Porcupine

The legend of the bore cap flying into space

The bore cap probably disintegrated?

Some ways to live-track space debris:

Astria Graph: http://astria.tacc.utexas.edu/AstriaGraph/

Heavens Above: https://www.heavens-above.com/

RTGs

A Texas space nerd came up with the Tesla Roadster payload

Janeidy Eve suggested launching the Tesla

The United Nations Space4Women

Tungsten dust could clean up space junk! Maybe.

Maintenance hole cover that shot into the sky, perhaps

The 1979 Skylab crash debris

The Kessler Effect and rubbish build up

Space tugboats? Theoretically, possibly!

Pioneer Venus Multiprobe craft with sapphire windows

Black Knight hypothetical alien object

'Oumuamua object: giant space turd? Alien ship?

For comments and inquiries on this or other transcripts, please contact OlogiteEmily@gmail.com